CPCRN
Cancer Prevention and Control Research Network

Technical Considerations: the past, present and future of simulation modeling of colorectal cancer

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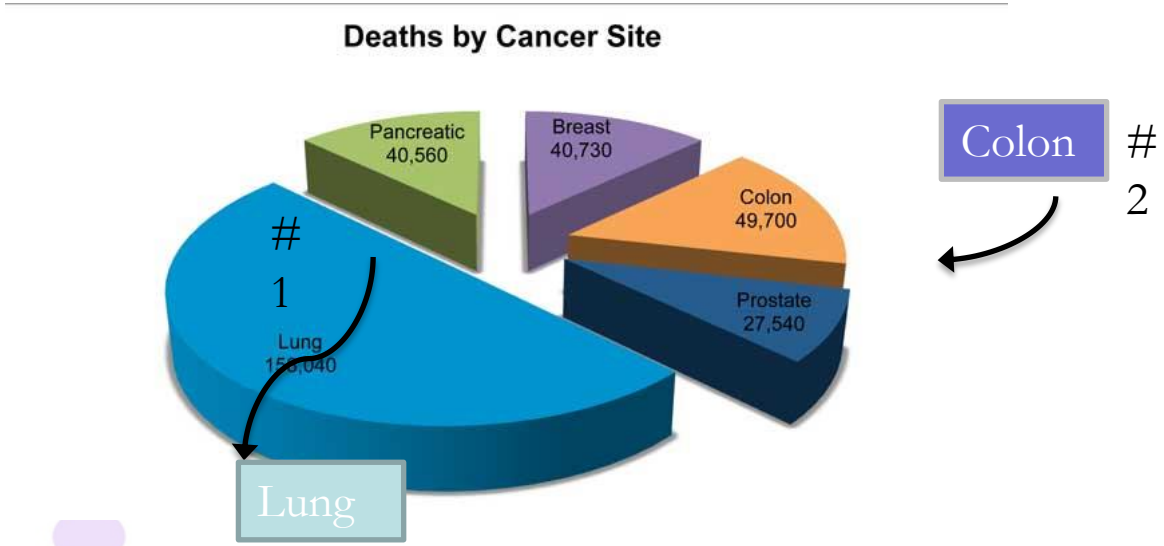
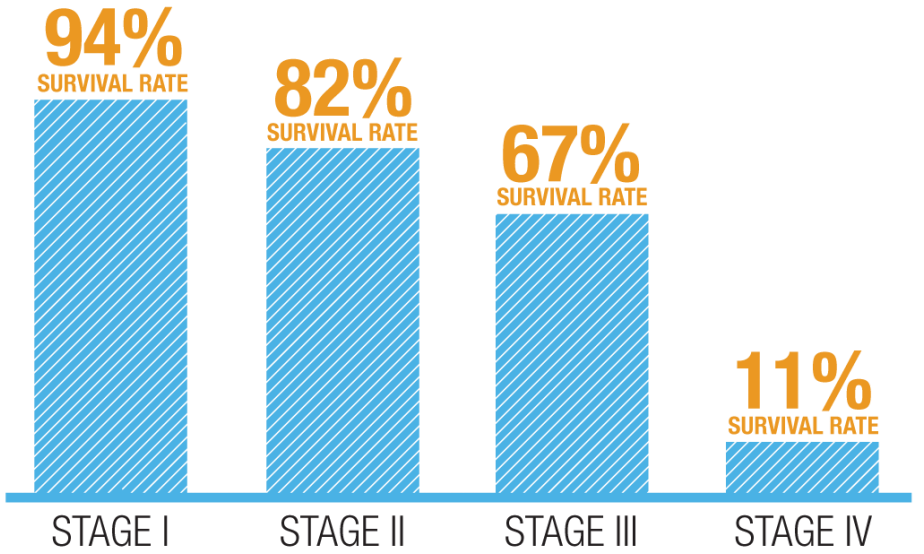
PRC Prevention Research Centers

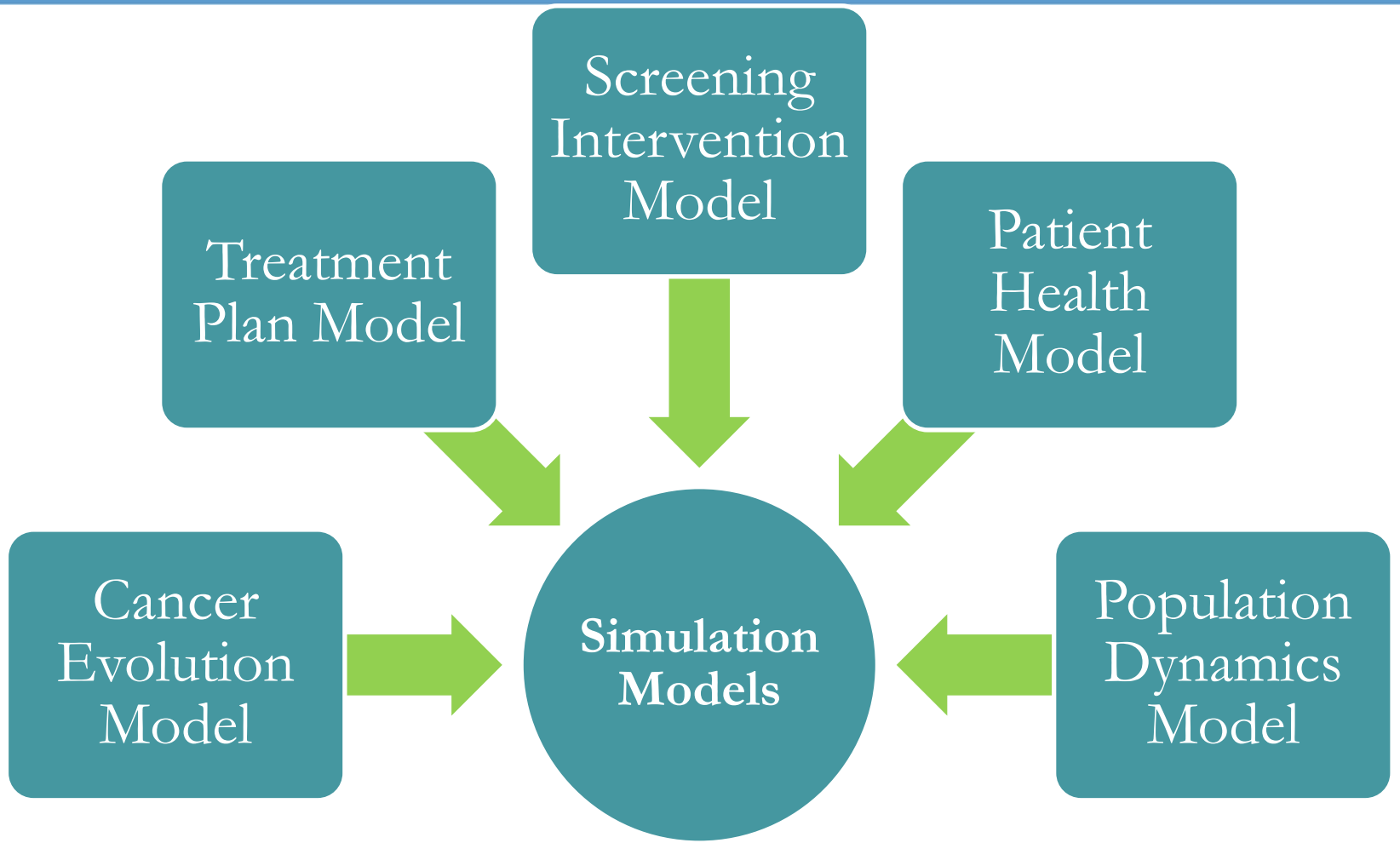
Background on Colorectal Cancer



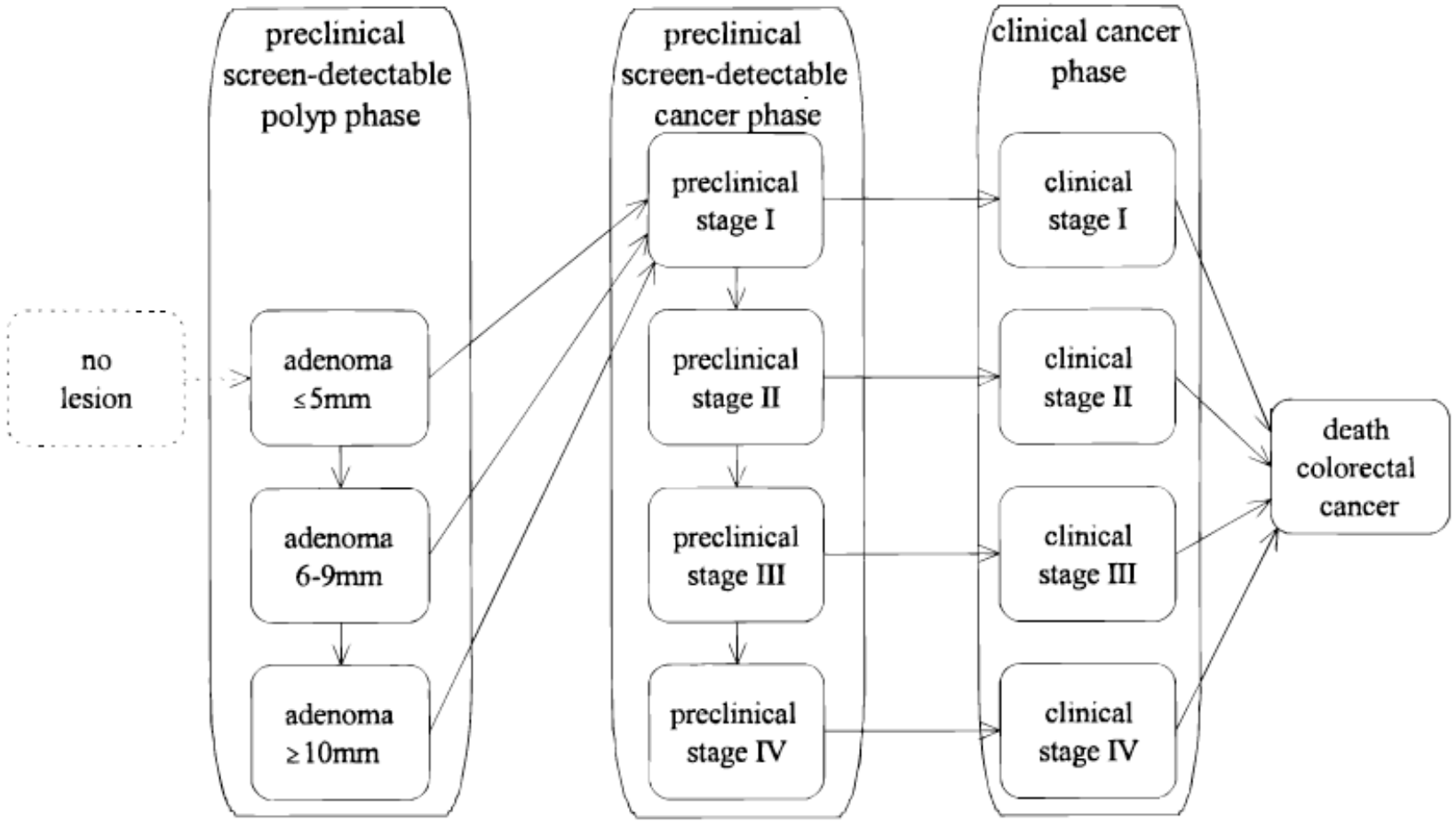


- In 2012 only about 65% of individuals were up-to-date with screening
- 27% had never screened
- Improving *screening rates* is a priority

Elements of CRC Simulation Models



Example Cancer Evolution Model



CRC Simulation Model Paradigms

Discrete Event Simulation Models

- Support for Individual Patient Simulation (IPS).
- Flexibility for patient-patient, patient-environment interaction.

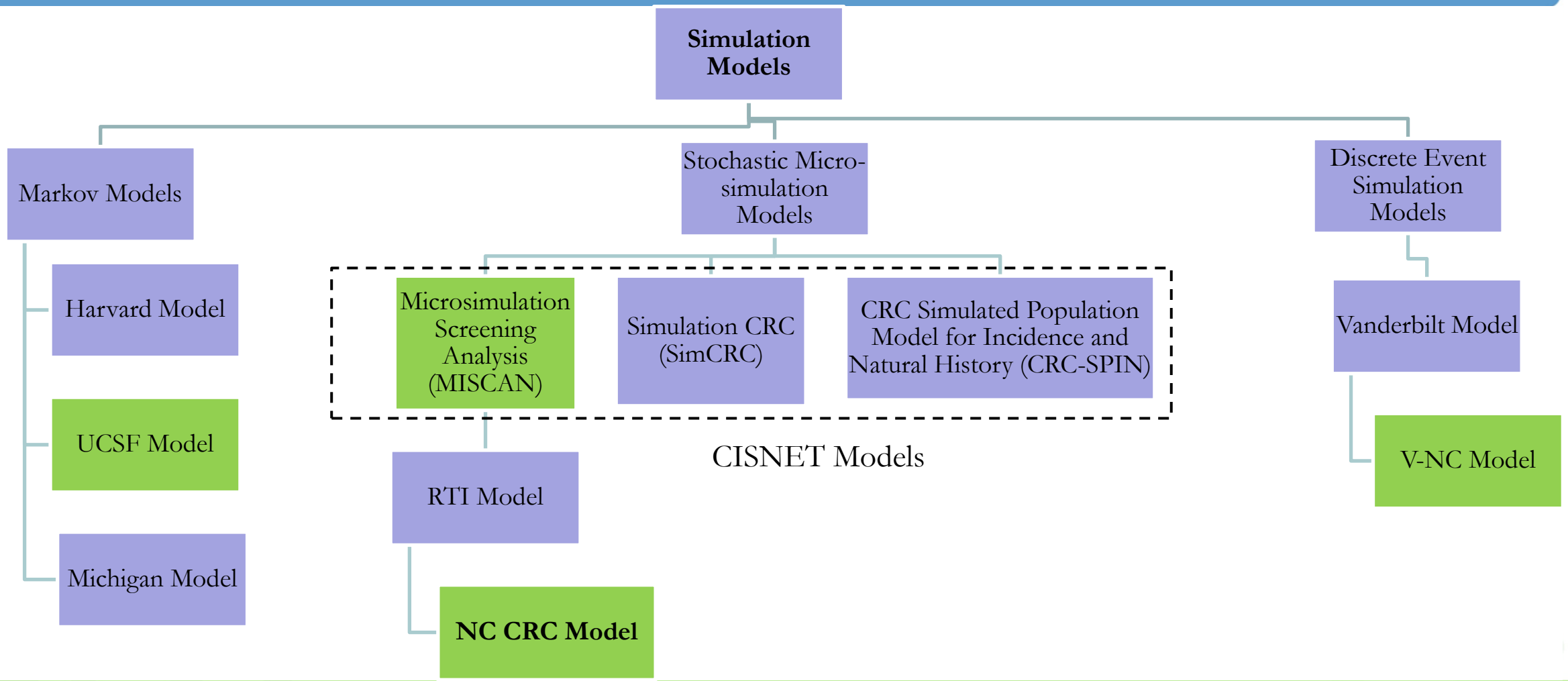
Markov Models

- Enumerate health states a person will experience during the course of the disease.
- The changes in state are described using transition diagrams very similar to flow charts.

Stochastic Microsimulation Models

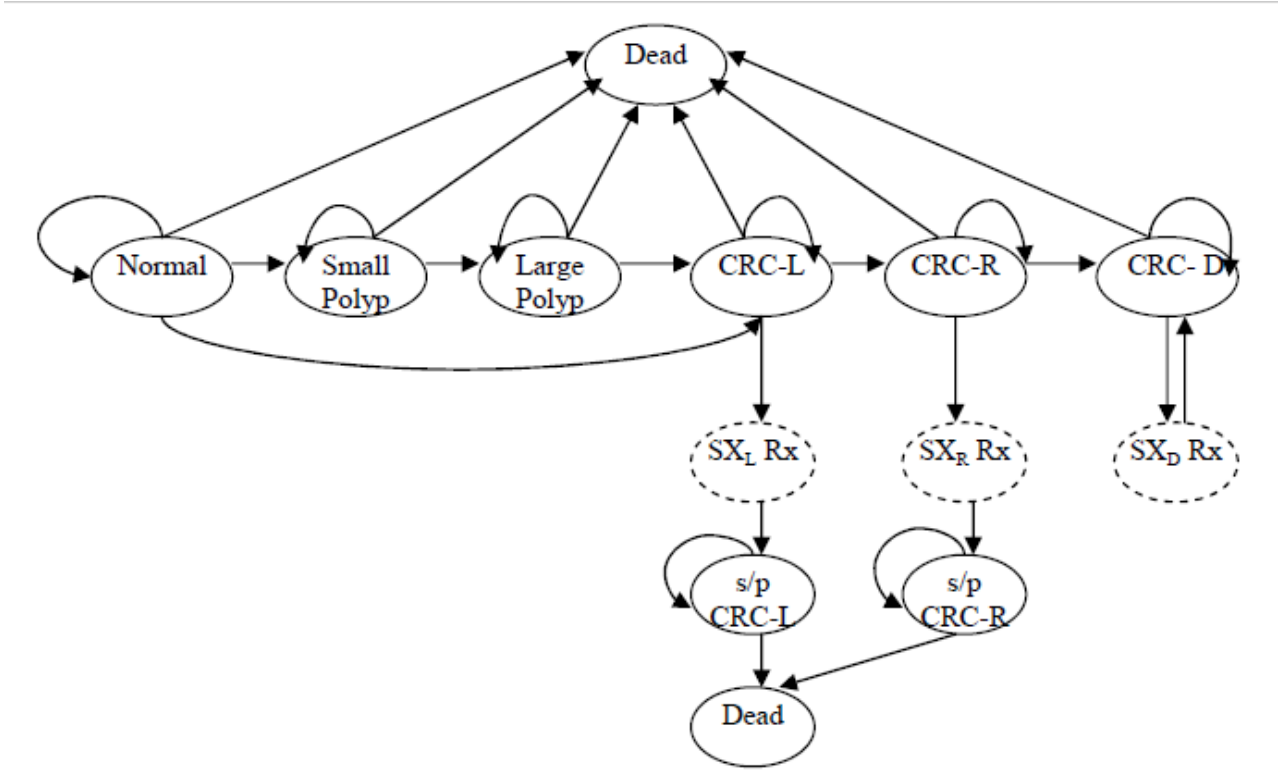
- "Stochastic" - Models simulate sequences of events by drawing from distributions of probabilities or durations.
- "Microsimulation" - persons are moved through the model one at a time.

CRC Simulation Model- Development History



Sample Markov Model Structure

- **UCSF (University of California, San Francisco) Model** - a cohort based Markov model from age 50 until death.
- Monte Carlo simulation that runs through the model 3500 times to determine approximate values for the percent of people in each state at a given time.
- Has a small probability for cancer to develop without developing from an adenoma.

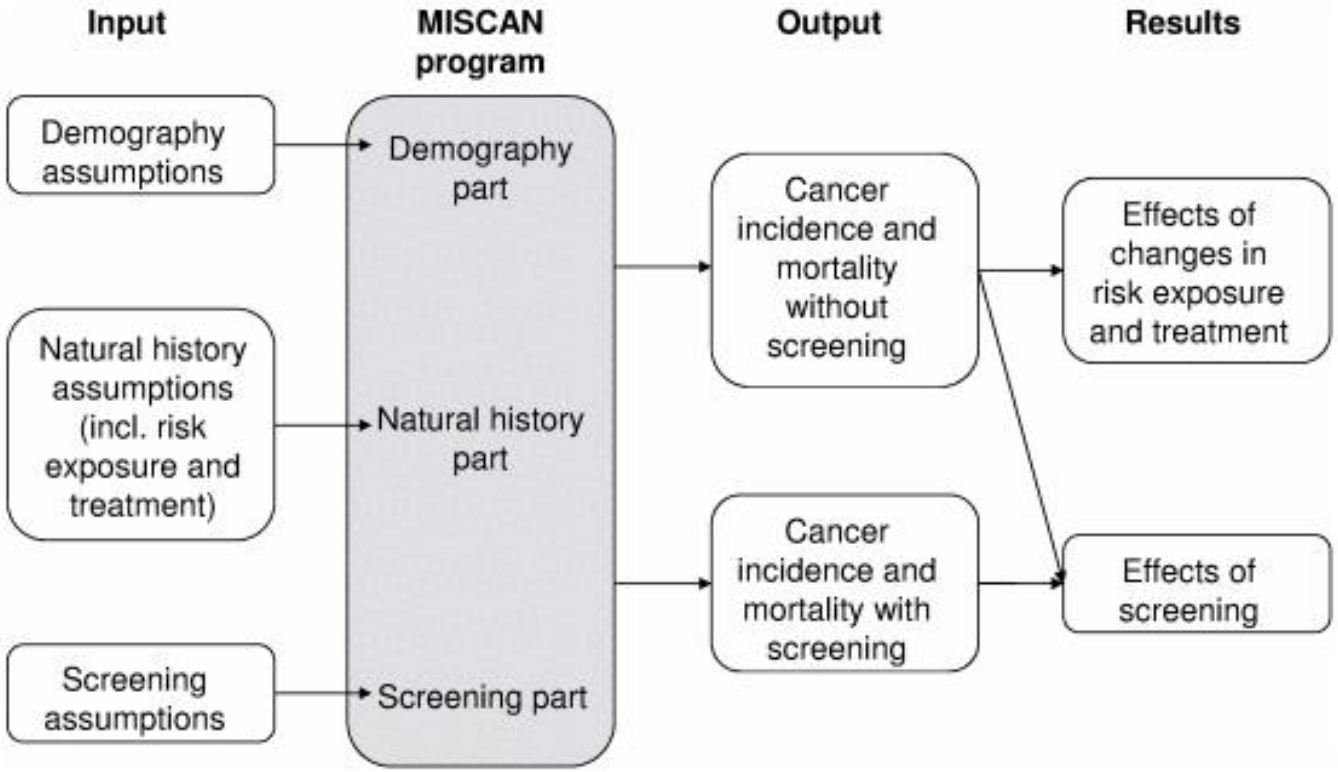


V-NC Model

- Primary Simulation Objects
  - Employs an **OOS** (Object Oriented System), driven by a model-independent database.
  - Allows for convenient modeling of causal and treatment pathways.
  - The primary object in the CRC simulation is the **person**.
  - The replication will be terminated when the person dies or when statistics collection ends.

MIcrosimulation SCreening ANalysis (MISCAN)

- MISCAN–Colon is a micro–simulation program, generating individual life histories.
- Uses the Monte Carlo method to simulate all events in the program.
- Possible events are birth and death of a person, adenoma incidence and transitions from one state of disease to another.



North Carolina Colorectal Cancer (NC-CRC) model

Outline-

- Designed to support decision making regarding population screening for colorectal cancer within the state of North Carolina.
- Simulates cancer incidence and mortality by stage, age and calendar year.
- The model can be used to test the effects of various interventions on life-years and costs by increasing an individual's probability of being screened for CRC.

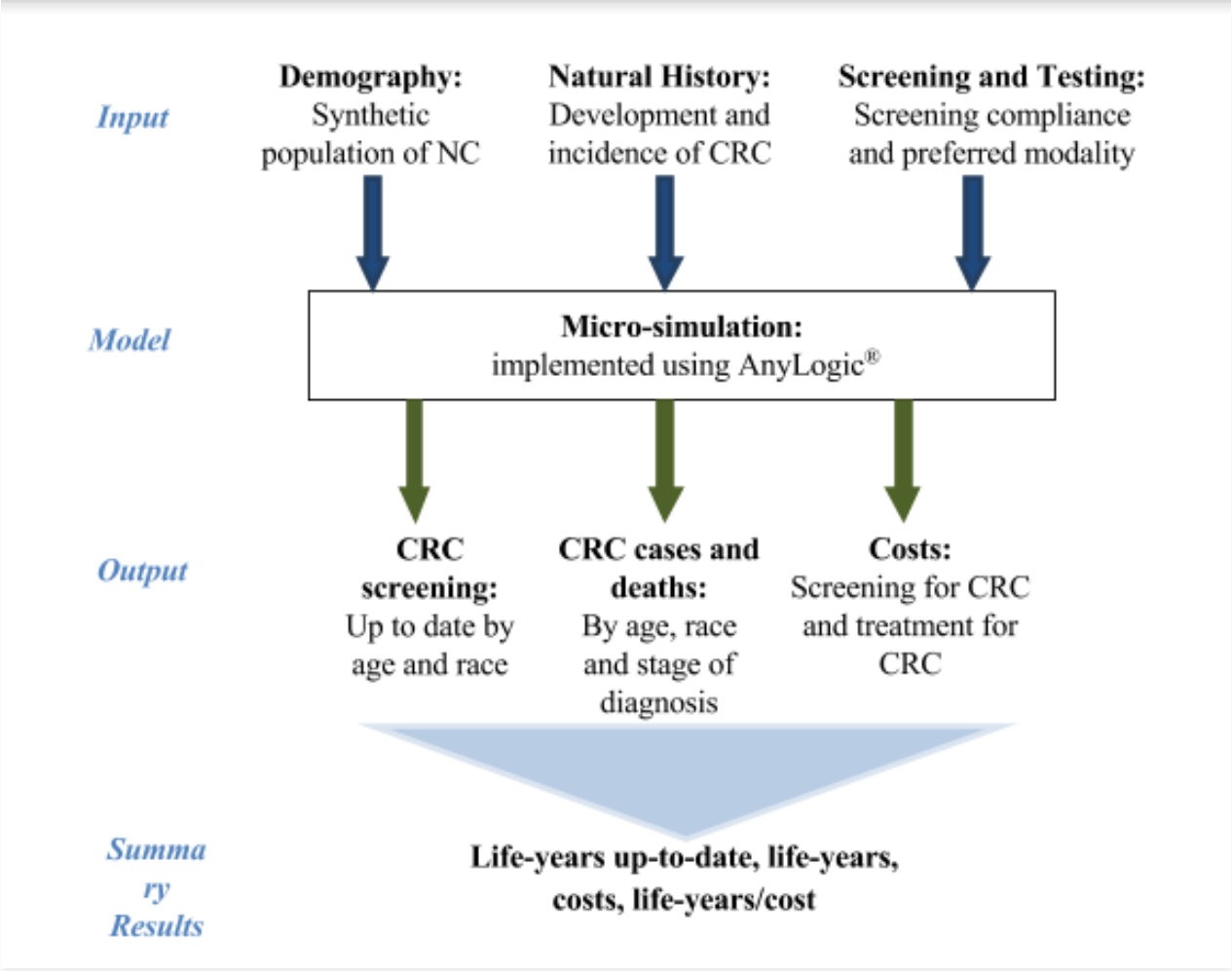
History-

- Based significantly on the MISCAN-COLON model (Loeve et al. 1999) and the work of Subramanian and colleagues. (2005)

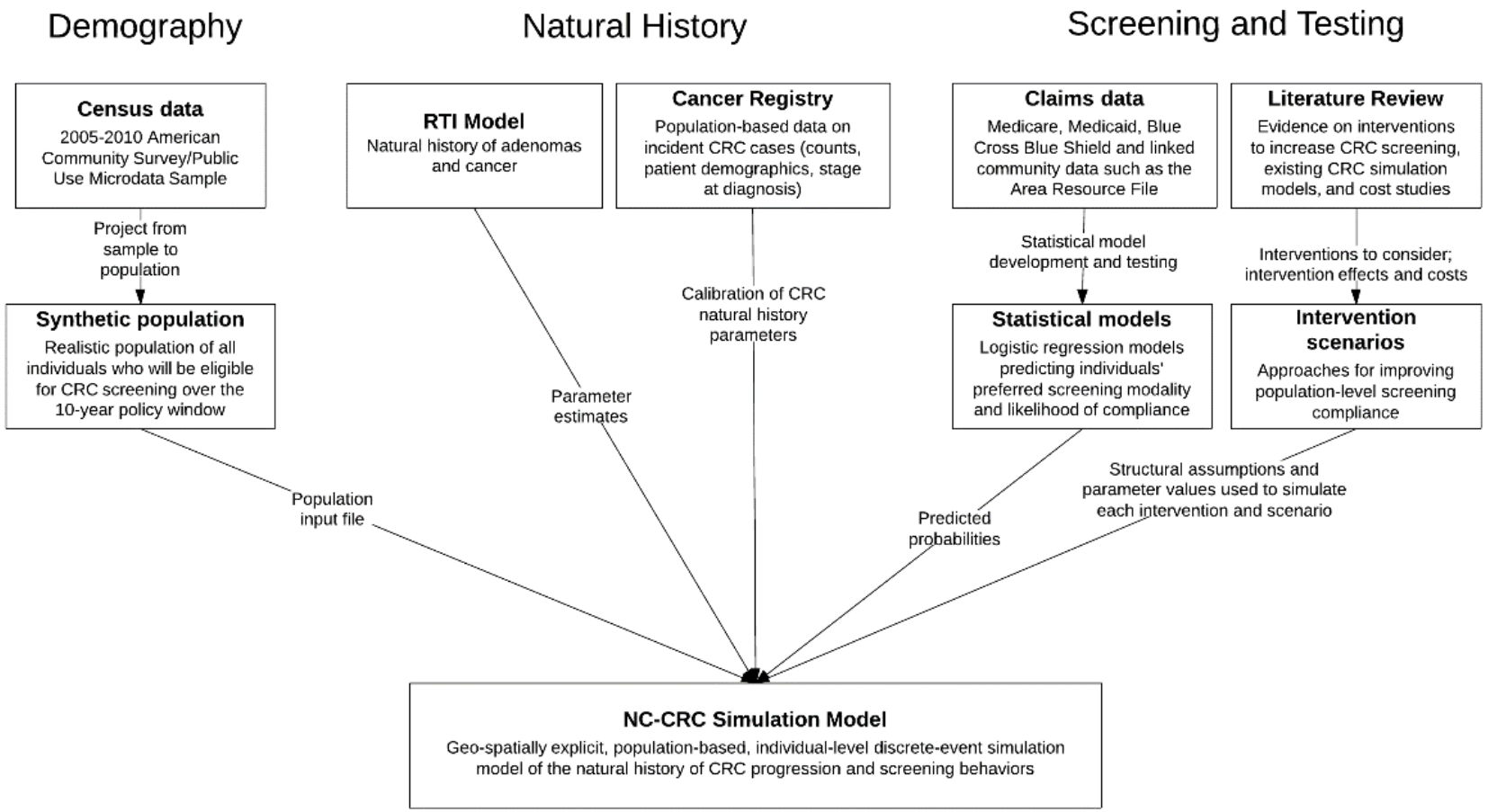
Expansion on other simulation models

- **Applying statistical models** from administrative claims data to predict the preferred screening modality of individuals and compliance with screening.
- **Calibrating natural history parameters** so that the incidence, age and stage of CRC diagnosis closely match registry data specific to the state of NC.
- **Models insurance** and allows status to change over time.
- Incorporating the effects of **population-level interventions** to increase compliance with CRC screening recommendations.

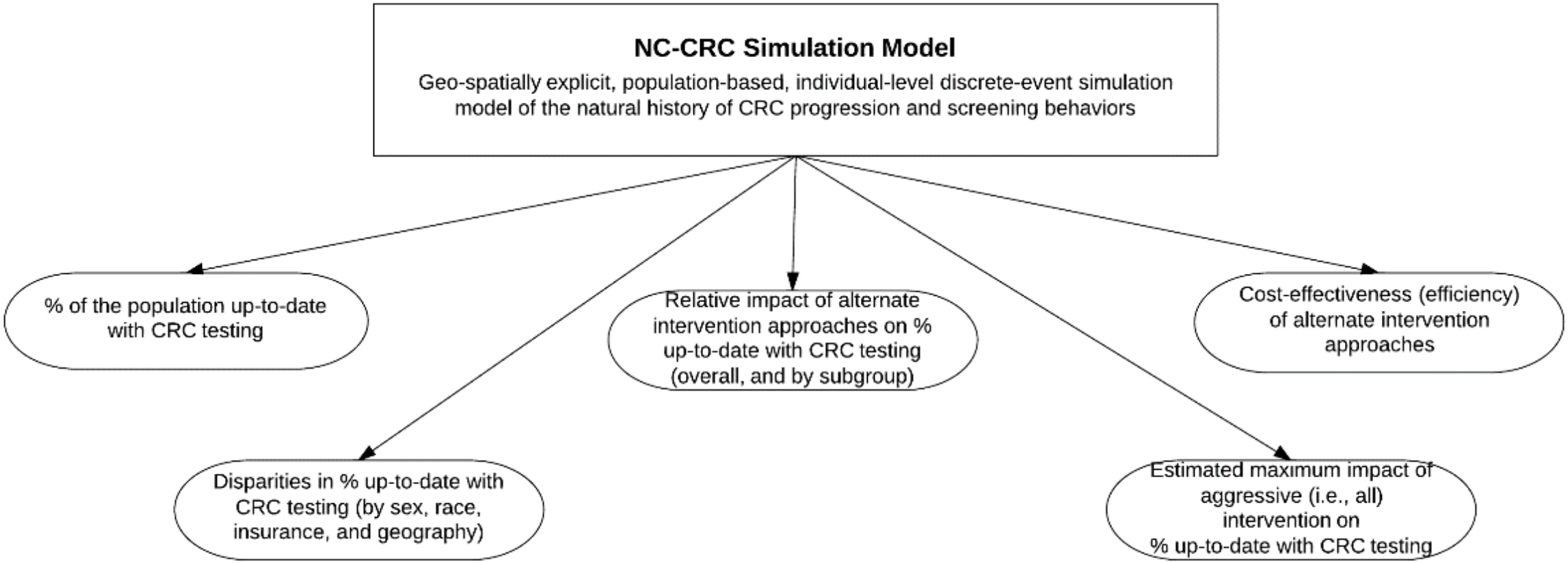
Model Structure



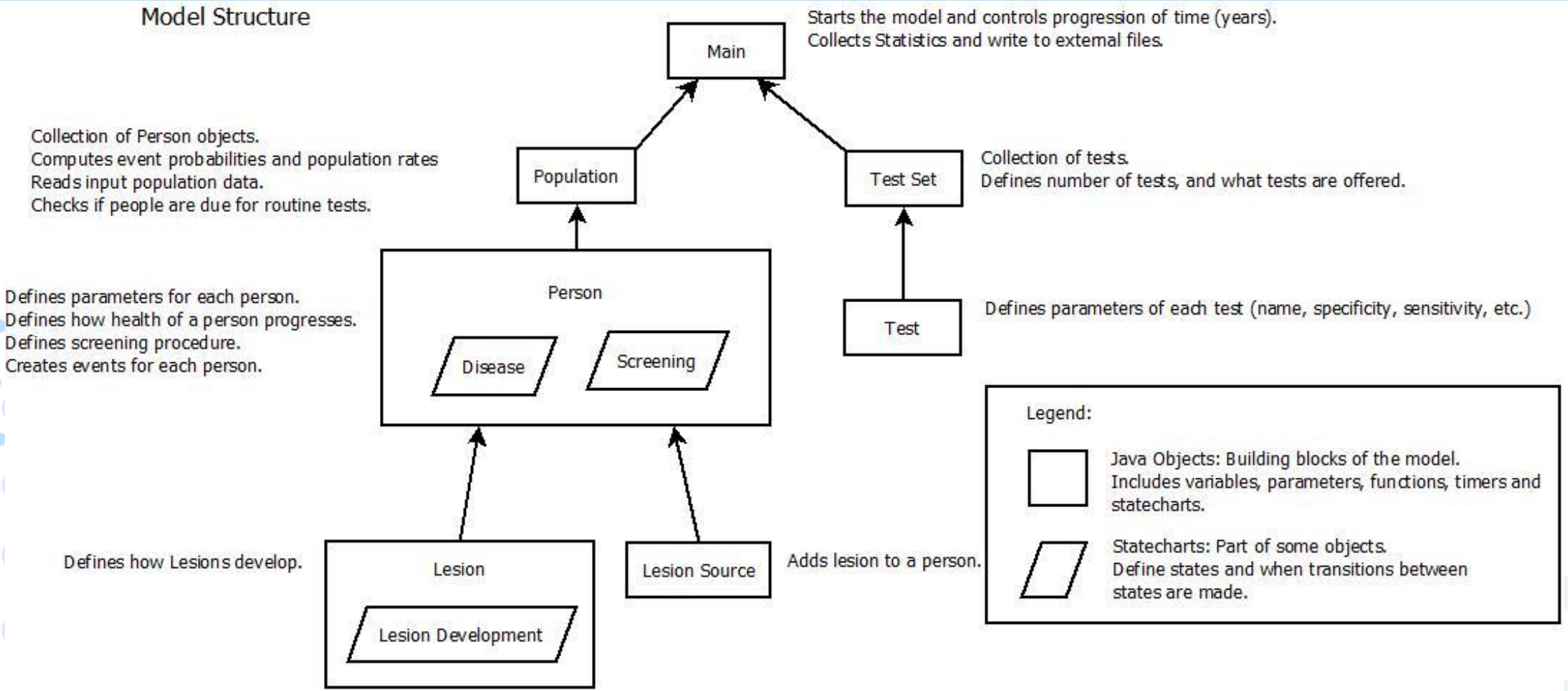
Elements of Models



Parameters- Output



Object Based Model Structure



Limitations and Challenges

- Model is highly data intensive.
- Meant to inform population guidelines and is based on general population trends.
- Model can end up requiring extensive computational resources.

Future of CRC Simulation Models

- Optimization algorithms to generate candidate follow-up strategies for specific patient subgroups.

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Questions/Discussions/Comments?

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Additional Slides

Assumptions(MISCAN)

- Demography Assumptions
  - The life table differs per birth cohort.
  - Death from colorectal cancer and death from other causes are considered independent from each other.
- Natural History Assumptions
  - Focus on the initiation, progression and response to treatment of colorectal cancer in the model.
- Screening Assumptions
  - Focus on all aspects of screening, including compliance and operational characteristics of the screening process.

Statistical Model Description

$$logit(\pi_{ij}) = Y_{ij} = \beta_{0j} + \sum_{k} \beta_k X_{ik} + \sum_{l} \beta_l X_{jk} + \epsilon_{ij}$$

$$\pi_{ij} = \frac{e^{Y_{ij}}}{1 + e^{Y_{ij}}}$$

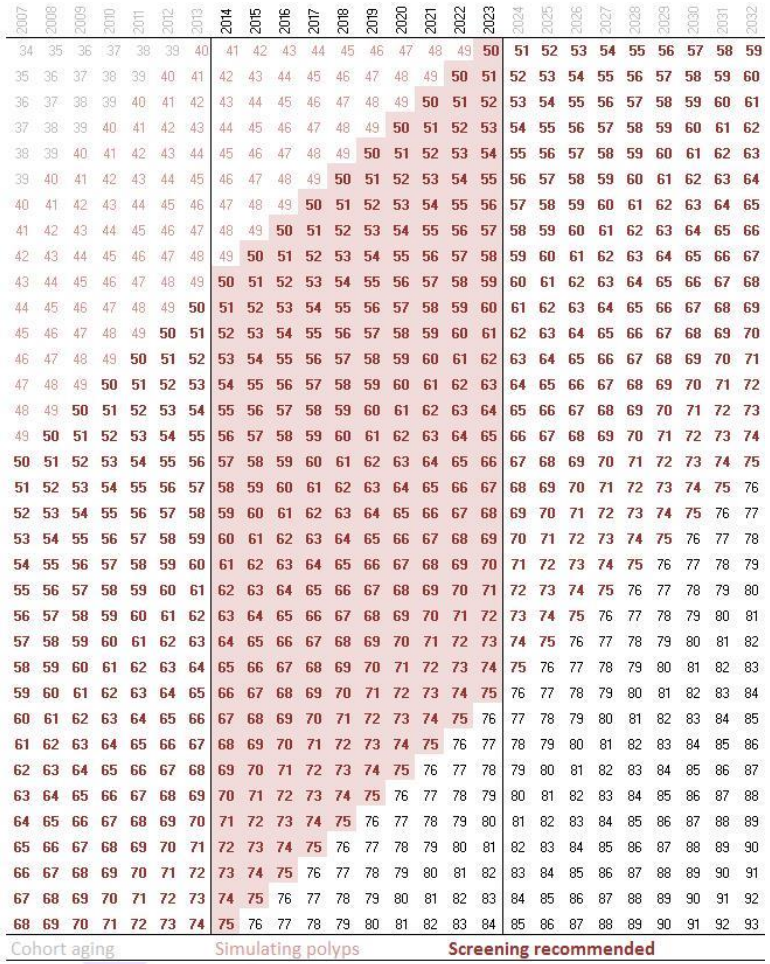
$\boldsymbol{\pi_{ij}}$ - Probability of binary outcome (CRC Screening vs No Screen or Colonoscopy vs FOBT) for person i at county j

$\boldsymbol{\beta_{0j}}$ - County level intercept

$\boldsymbol{X_{ik}}$ - Person level attributes (race, gender, etc)

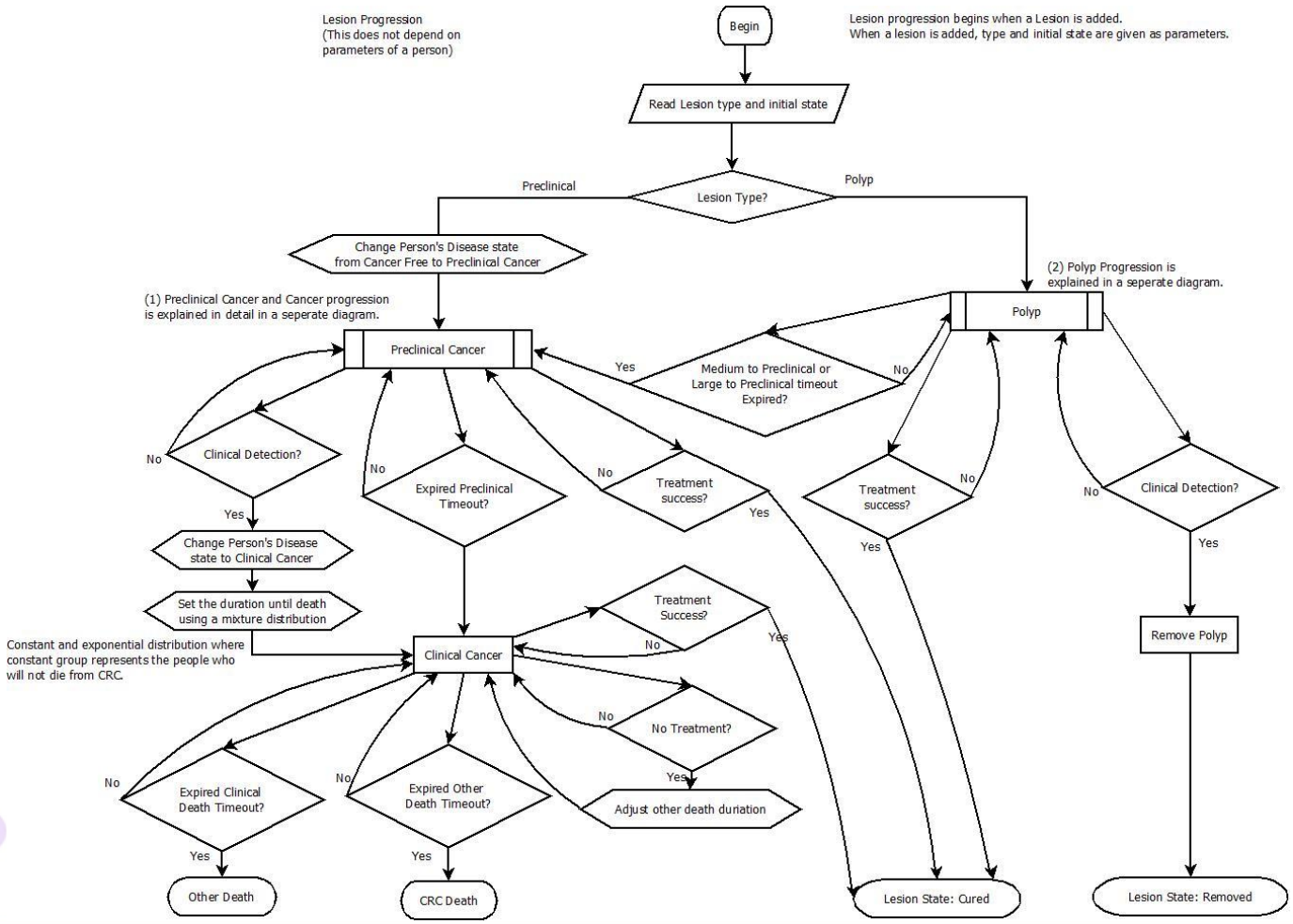
$\boldsymbol{X_{jk}}$ - County level attributes (distance to endoscopy facility)

Age Cohorts Included In Model

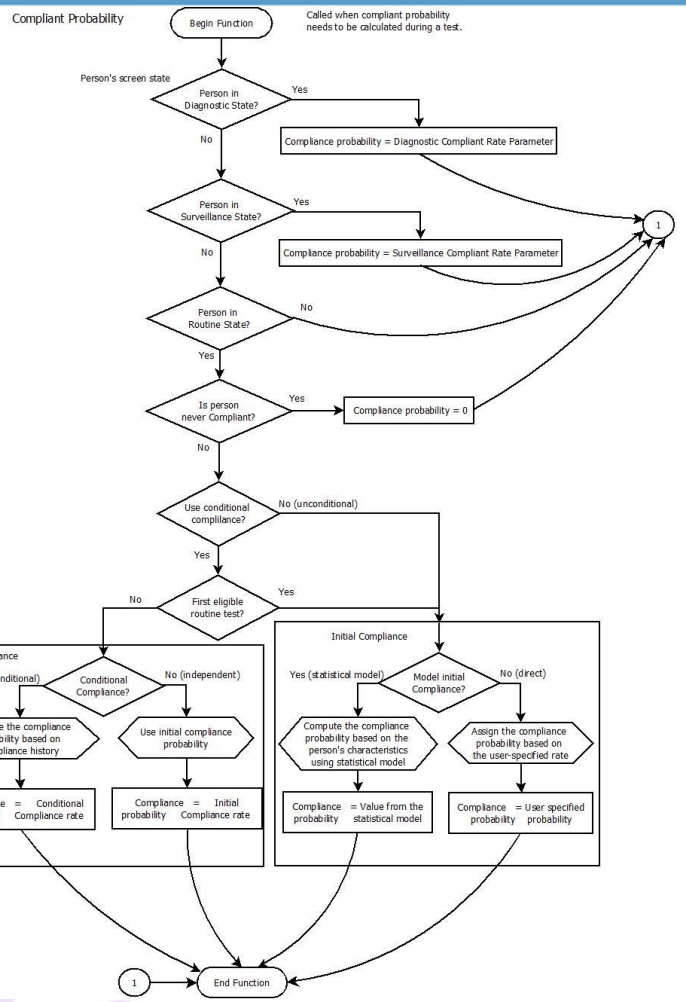


- Age;
- Sex;
- Race (white, black, Hispanic, other);
- Smoking status (current, former, never);
- Household income (<$25,000, $25,000-<$50,000, ≥$50,000);
- Insurance status (none, private, Medicare, Medicaid, dual Medicare and Medicaid);
- Education (not complete college, completed college);
- Residential location (zip code).
- State health insurance program participation (SHEP, not a participant, participant)
- Marital status for privately insured individuals (married, unmarried, unknown)

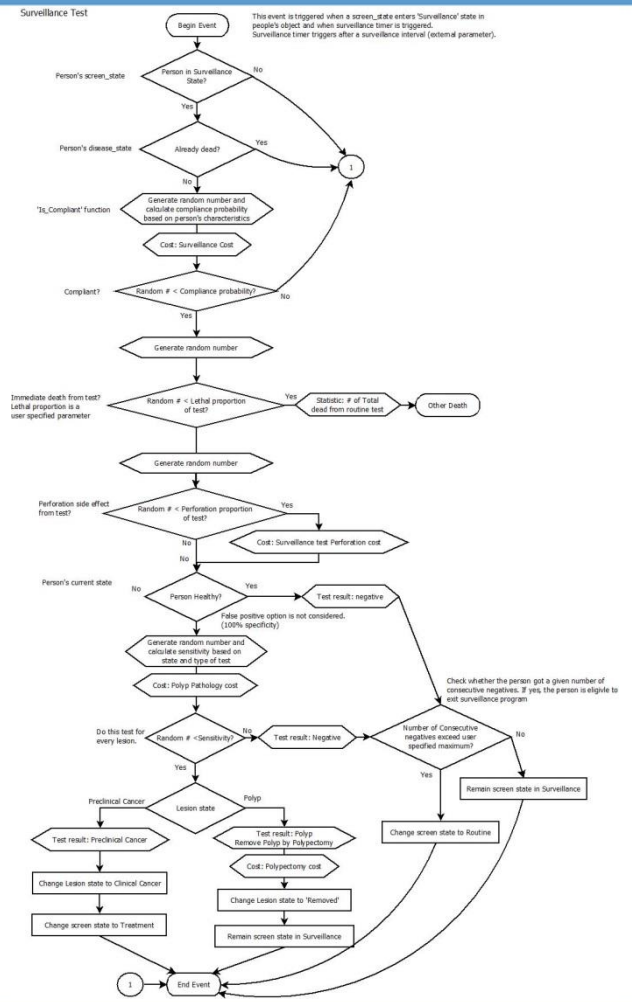
Process flow of lesion progression



Compliance process flow



Testing process flow



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